AC 2009-2316: WHY AREN'T THERE MORE STUDENTS WITH DISABILITIES IN ENGINEERING?

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Introduction

Students with physical disabilities are underrepresented in STEM (Science, Technology, Engineering, and Mathematics). According to the NSF (National Science Foundation)[1], "a higher percentage of students with disabilities than of those without disabilities drop out of high school. Among students who were eighth graders in 1988, 10 percent of those with disabilities and 6 percent of those without disabilities had dropped out of school by 1994. Students with disabilities were less likely than those without to have received a high school diploma by 1994. Dropout and graduation rates vary by type of disability, with those with visual, hearing, or speech impairments least likely to have dropped out. Those with orthopedic impairments, learning disabilities, or "other" disabilities (including health problems, emotional problems, mental retardation, or other physical disabilities) were most likely to have dropped out". National Education Longitudinal Study indicates that students with disabilities may be less academically prepared for college than those without disabilities: they were more likely to have taken remedial courses, less likely to have taken advanced placement courses, and had lower grade point averages and lower SAT scores (NCES 1999d). Among 1998 college freshmen, students with disabilities were more likely than those without to have earned Cs and Ds in high school. They were less likely to have met the recommended years of high school study in mathematics, biological sciences, and physical sciences; and to have spent more time between high school graduation and entry into college (Henderson 1999). The opportunity to study, conduct research, and establish a career in these fields is a reachable goal for students regardless of physical ability.

It is the goal of this paper to present some discussions and plans of action for providing long-term opportunities for university students with physical disabilities studying engineering and technology. At larger scale, this goal applies to both undergraduate and graduate students. However, in this paper we only discuss issues as they relate to undergraduate engineering and technology studies. We concentrate on engineering and technology, but we use STEM (Science, Technology, Engineering, and Mathematics) notation throughout this paper, as is commonly used by institutions of higher education, by National Science Foundation (NSF), and by many professionals performing research and teaching in this area. The long-term plan is to help students with disabilities to achieve a high level of success, both academically and professionally, through the removal of architectural, technological, and societal barriers that presently exist. Using this plan, we wish to create a model program that targets students who are physically disabled in order to increase the proportion following STEM curricula. Students with disabilities make up about 6 percent of all students enrolled in postsecondary institutions; 5.7 percent of all students who major in S&E fields and 6.6 percent of students who major in non-S&E fields. Presented here are some suggested programs that may help with this goal. We use our empirical observations as well as the observation of the others in this field to draw some of our conclusions.

Middle/High School Student Outreach

For many years, student outreach programs have been employed for many different student population including minorities and those with physical disability. By all accounts, outreach programs work in increasing the interest in STEM fields by middle and high school students with disabilities. It has been tried at many institutions of higher education including the University of Arizona, the University of Washington (Seattle), and the New Mexico State University, to name a few. For students with physical disability, this is accomplished more effectively through mentoring by current STEM students with disabilities and faculty, who travel to schools meeting with students. Future contacts will be maintained via the internet, creating a peer network, depending on the size of the network.

The size and frequency of any outreach program depends on the resources availability and funding allocation, we believe. Some outreach programs may include one visit per school per month while others include more. The size of the targeted school district and the student population also affect the outreach efforts. Initially, the target should be schools that serve the largest population of students with physical disabilities. This varies from school to school and from district to district. The size of the team sent to each school will depend on the size of the expected audience, but shall consist of one to three students who are disabled and the same number of STEM faculty. Participating students and faculty should attend workshops and training sessions specifically designed for them. Each visit is best suited if it includes an overview of STEM disciplines by the faculty, while the students' role is to share their own experiences in these areas. The students will share their experiences as to how students who are disabled can overcome their disabilities by performing experiments normally thought unachievable, e.g. a visually impaired student using a graphical interface to interpret a graph, or a mobility impaired student using a computer simulation of dropping a ball from a platform to understand the effect of gravity. The middle/high school students will then participate in similar hands-on tasks, e.g. measuring a voltage with a voltmeter; mixing chemicals; conducting a pendulum experiment; measuring distance with an ultrasonic gauge.

Middle/High School Counselor/Teacher Training Workshops

For many students with disability, the advice of the school counselors and teachers is found to be a decisive factor in pursuing career choices in STEM. There needs to be more education for school counselors and teachers focusing on strategies to encourage students with disabilities to pursue a career in a STEM field. To encourage the counselors and teachers to attend workshops some sort of credit should be provided to the workshop attendees. This may include continuing education credits, certificates, or some kind of a monetary compensation. The duration of these workshops depends on the content and the number of attendees. The most effective workshops are those conducted by STEM faculty and students who are physically disabled.

These workshops will design, develop, and implement disability awareness workshops for Middle and High School Counselors and Teachers. The workshops are intended to

encourage these counselors and teachers to recognize a student's interest in STEM and to assist students with disabilities who have the potential of seeking entry to university level STEM programs.

The workshops will consist of several modules that include a literature review, lectures, discussions, and sensitivity training. The literature will describe the types of disabilities while the lectures and discussions will center on the impact of disabilities as well as the psychosocial aspects of those disabilities. The sensitivity training module includes role playing and simulation to explore the interaction of a student with a disability and his/her environment. The workshop will also focus on the barriers to learning that are often apparent yet frequently overlooked within the classroom, laboratories, campus, and community.

School teachers are continually challenged with their task to teach 30 or more students, four or more times a day. If we add to that task the need to accommodate a student with a disability, then the challenge may become overwhelming and may cause the teacher to be less effective. The goal of the workshops is to provide these teachers with a working knowledge of accommodations and accessibility information that will readily assist them in making the teaching of science and math courses a pleasant experience for themselves and their students. Teachers will explore accommodation and accessibility issues, learn some tips for teachers and students regarding accommodation and access, and understand the implications of the Individualized Education Plan for Students with disabilities, together with other ideas that make science and math courses more accessible to students with disabilities. The workshop will be open to all teachers depending on the targeted school district.

Mentoring Undergraduate Students

The list is mentoring programs across the U.S. institutions o higher education is large. Our experience with mentoring undergraduate students with physical disability has been extensive, and we feel that we can make accurate, but empirical recommendations.
In the same way that the middle and high school students with physical disabilities can benefit from a mentoring program, so too can undergraduates. For reasons similar to those described in Middle/High School Student Outreach, this mentoring program should be viewed as students helping other students. This attitude makes the whole relationship between mentor and mentee more casual and productive.

Mentors should be trained under carefully crafted programs and workshops. Mentors and mentees will be matched based on the following characteristics: *(a)* the same major field of study, *(b)* the same department or college, and *(c)* similarities in disabilities (e.g. matching mobility impaired to mobility impaired). The size of the pool of mentors helps with the freedom of the program, so larger pools are more desirable. The main point is to match persons that have enough in common that empathy is possible. The overriding principle is "Keep it loose, but make it work." Mentoring duties will include: *(a)* acting as a sounding board, friend, advisor, example, role model, or buddy, *(b)* acting as an advisor in "dealing" with a disability in the University environment, and *(c)* giving advice

and assistance in "how to succeed at the University", (e.g. how to study, time management, stress reduction, priorities). The students' office for students with disability that facilitate student academic support can serve as resource for mentees recruitment efforts. Mentees can eventually be invited to become mentors.

Industry Outreach

STEM professionals in industry and education can effectively mentor middle and high school, undergraduate and graduate students, all with disabilities with the intent of changing industry climate and expanding career options. Mentors provide evidence that a STEM career is an attainable goal. It is essential to identify and draw STEM professionals willing to share their individual formulas for success in industry and education with students. What better teacher than one who overcame obstacles the student has yet to face. To recruit STEM professionals, there are many strategies to use. For example, principals of local companies in STEM fields, especially electronics, optics, aeronautics, biomedical engineering, defense, and the computer industry, can be contacted in person, email, and by phone to solicit support in identifying possible mentors. A mentors training it to be held at each interested firm. Mentors and mentees will complete an information profile, and suggestions will be provided for interaction—personally, through phone, and the internet. Visits to firms will be encouraged.
The outreach team must have a leader that is familiar with the nuts and bolts of the game.

Summary and Concluding Remarks

While at the very beginning of conception, it is the goal of this paper to present some discussions and remedial plans of action for providing long-term opportunities for university students with physical disabilities studying engineering and technology. Although this goal applies to both undergraduate and graduate students we limit our discussions here as they relate to undergraduate studies. We concentrate on engineering and technology, but we use STEM (Science, Technology, Engineering, and Mathematics) abbreviation throughout this paper. The long-term plan is to help students with disabilities to achieve a high level of success, both academically and professionally, through the removal of architectural, technological, and societal barriers that presently exist. Presented here are some suggested programs, limited in discussions but overall in goals, that may help with achieving this goal. We use our empirical observations as well as the observation of the others in STEM fields to draw some of our conclusions. The effectiveness of such programs are complicated to measure but the impact is long-lasting and life-changing for many students across STEM disciplines.